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ABSTRACT

Focusing on metalworking occupations, this document is one in a series of forty-one reprints from the Occupational Outlook Handbook providing current information and employment projections for individual occupations and industries through 1985. The specific occupations covered in this document include blacksmiths, forge shop occupations, welders, foundry occupations (pattern makers, molders, coremakers), and machining occupations (all-round machinist, instrument makers, machine tool operators, setup workers, and tool-and-die makers). The following information is presented for each occupation or occupational area: a code number referenced to the Dictionary of Occupational Titles; a description of the nature of the work; places of employment; training, other qualifications, and advancement; employment outlook; earnings and working conditions; and sources of additional information. In addition to the forty-one reprints covering individual occupations or occupational areas (CE 017 757-797), a companion document (CE 017 756) presents employment projections for the total labor market and discusses the relationship between job prospects and education. (BM)

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Metalworking Occupations

Reprinted from the
Occupational Outlook Handbook,
1978-79 Edition.

U.S. Department of Labor
Bureau of Labor Statistics
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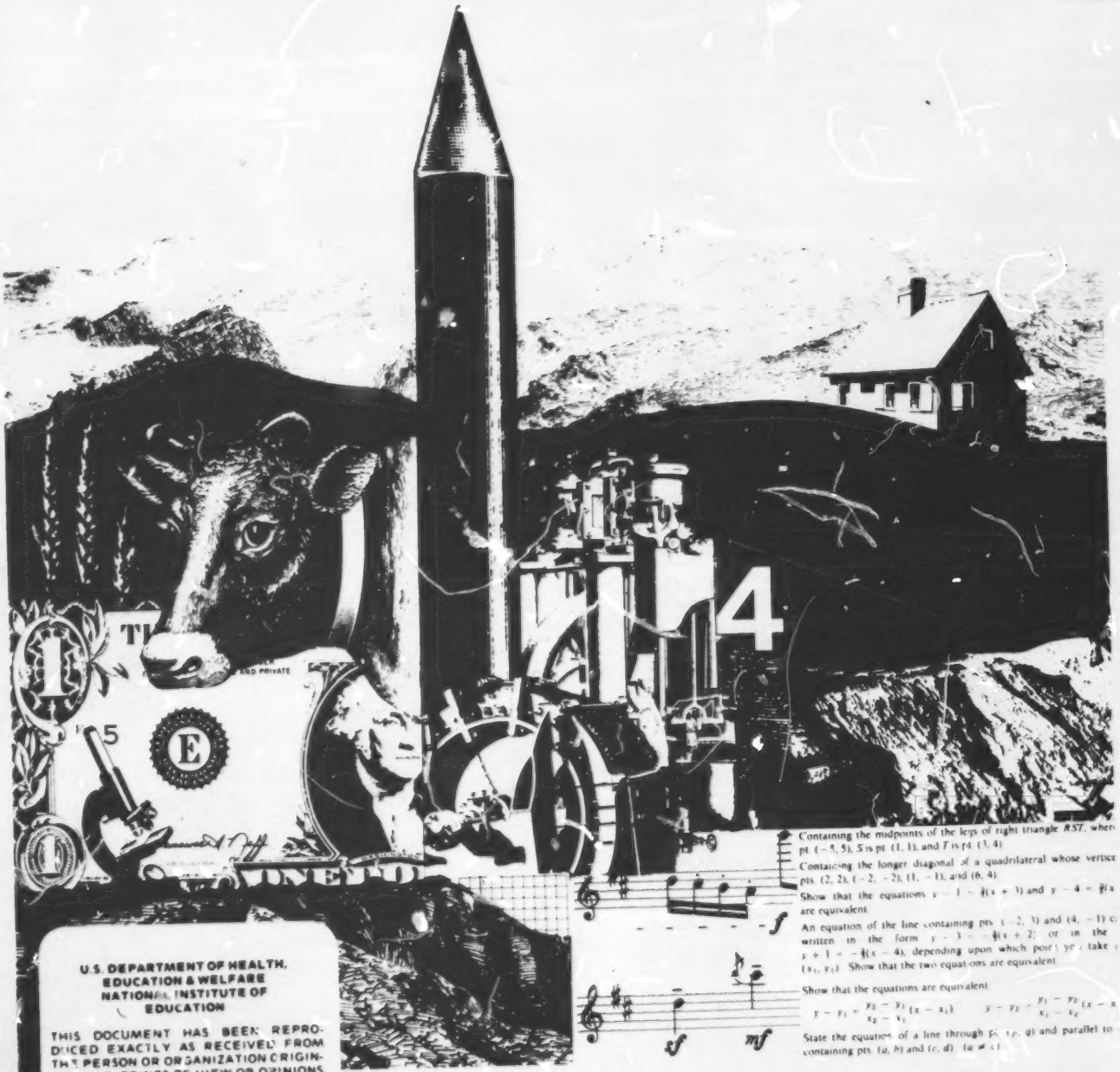
Bulletin 1955-2



Containing the midpoints of the legs of right triangle *RST*, where pt. (−5, 5), *S* is pt. (1, 1), and *T* is pt. (3, 4)

Containing the longer diagonal of a quadrilateral whose vertices pts. (2, 2), (−2, −2), (1, −1), and (6, 4)

Show that the equations $y - 1 = \frac{1}{2}(x + 3)$ and $y - 4 = \frac{1}{2}(x$ are equivalent.

An equation of the line containing pts. (−2, 3) and (4, −1) c written in the form $y - 3 = -\frac{2}{3}(x + 2)$, or in the $y + 1 = -\frac{2}{3}(x - 4)$, depending upon which point you take (x_1, y_1). Show that the two equations are equivalent.

Show that the equations are equivalent.

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1) \qquad y - y_2 = \frac{y_1 - y_2}{x_1 - x_2}(x - x$$

State the equation of a line through pt. (*p*, *q*) and parallel to containing pts. (*a*, *b*) and (*c*, *d*). ($a \neq c$).

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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CE 017 757

BLACKSMITHS

(D.O.T. 356.381 and 610.381)

Nature of the Work

Years ago the village blacksmith was as vital to a community as the country doctor. No one else could repair a broken wagon wheel, shoe a horse, or forge a tool to suit a farmer's needs. Today, the blacksmith's work still is important in factories and mines where heavy metal equipment must be repaired, and at stables and racetracks. Power hammers and ready-made horseshoes have made much of the work easier, but the basic tasks remain largely the same.

The first thing a blacksmith must do when making or repairing anything made of metal is to heat it in a forge to soften it. Once the metal begins to glow red, it is ready for the blacksmith to pick it up with tongs, place it on the anvil, and begin to shape it using presses and power hammers. On repair jobs broken parts are rejoined by hammering them together. The blacksmith uses handtools such as hammers and chisels to finish the task at hand, often reheating the metal in the forge to keep it soft and workable.

Before a metal article can be used, it must be hardened. To complete this stage of the process, the blacksmith reheats the metal to a high temperature in the forge and then plunges it into a water or oil bath. However, metal hardened in this way is brittle and can break under stress. If strength is important, blacksmiths temper the metal [illegible]. To do this, they heat the metal to a lower temperature than they use for hardening, keep it hot for some time, and then allow it to cool at room temperature.

Blacksmiths who specialize in shoeing horses are called farriers. Today, most farriers use ready-made horseshoes so that their primary job is to adjust shoes for a proper fit. On some occasions, however, they may have to make the shoes themselves. Racehorses need special care because they must withstand strenuous punishment to their legs and hooves. Improper shoeing can permanently damage a valuable horse. Farriers who shoe racehorses need to be able to recognize weaknesses in a horse's legs, and shoe it accordingly. Some horses, for example, need shoes that are thicker on the outside as compared to the inside edge in order to walk correctly. To shoe a horse, farriers begin by removing the old shoe with nail snippers and pincers. They examine the horse's hoof for bruises and then clean, trim, and shape the hoof. When the hoof is ready, they position and nail a shoe onto the hoof and finish by trimming the hoof flush to the new shoe.

Industrial occupations that are similar to blacksmith include forge and hammer operator, welder, and boilermaker. (These occupations are discussed elsewhere in the *Handbook*.)

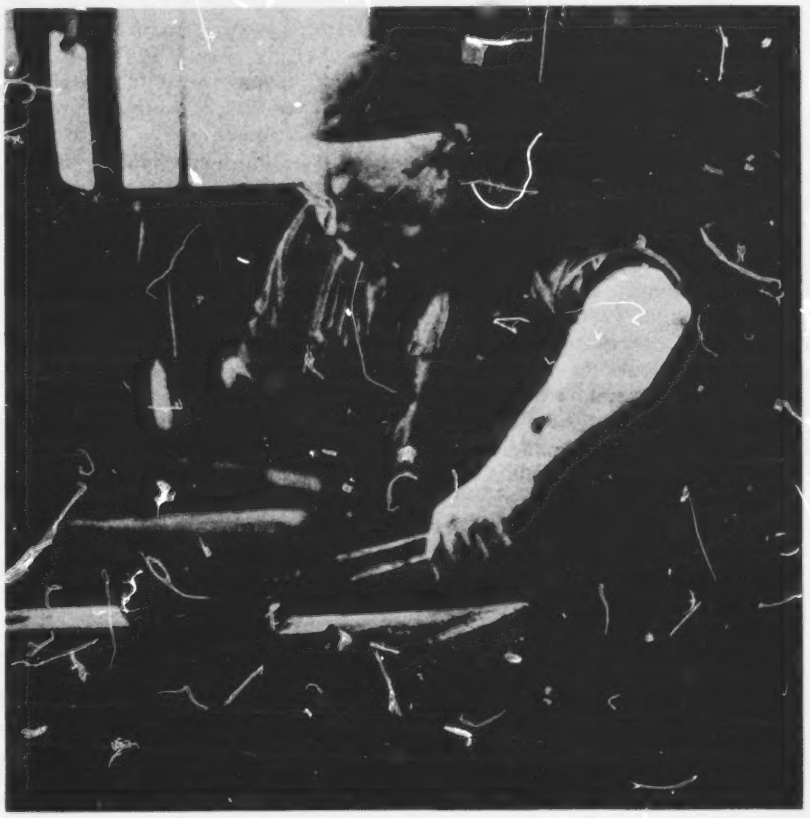
Places of Employment

Of the approximately 10,000 blacksmiths employed in 1976, almost two-thirds worked in factories, railroads, and mines. The remainder worked in small shops, and most were self-employed. Blacksmiths work in all parts of the country—in rural communities as well as in large industrial centers.

Most farriers are self-employed and contract their services to horse trainers at racetrack stables and to owners of horses used for private or public recreation.

Training, Other Qualifications, and Advancement

Many beginners enter the occupation by working as helpers in blacksmith shops or large industrial firms that employ blacksmiths. Others enter through formal apprenticeship programs and transfer from related occupations such as forge operator or hammer operator. Apprenticeship programs usually last 3 or 4 years. The programs teach blueprint reading, proper use of tools and equipment, heat-treatment of metal, and forging methods. Most apprentices are found in large industrial firms rather than in small repair



Many beginners work as helpers in blacksmith shops.

shops. Vocational school or high school courses in metalworking and blueprint reading are helpful to persons interested in becoming blacksmiths.

Many farriers learn their craft by assisting experienced farriers. Others may take a short course in horseshoeing lasting about 3 or 4 weeks before gaining experience on their own or as farriers' assistants. Courses in horseshoeing are taught in several colleges, as well as at private horseshoeing schools. Most of these are located in the Midwest. Persons considering enrolling at any school should talk to a farrier in their area concerning the school's performance in producing qualified farriers. At least 3 to 5 years of special training or experience are needed to obtain the skills necessary to shoe racehorses.

Farriers who wish to work at racetracks must pass a licensing examination. During the examination, they must demonstrate their knowledge of corrective shoeing techniques and the proper shoe to use depending on the condition of the horse's hoof or leg, and the condition of the racetrack. The examination is a performance test and does not require a written examination.

Blacksmiths must be in good physical condition. Pounding metal and handling heavy tools and parts require considerable strength and stamina. Farriers, of course, must have the patience to handle horses.

Opportunities for advancement are limited, especially for blacksmiths who work in small repair shops. However, blacksmiths may advance to be supervisors or inspectors in factories, or decide to open their own repair shops. Blacksmiths also may be able to transfer to related occupations such as forge, hammer, and press operators.

Farriers may open their own shops or travel from job to job with a portable forge, if one is needed. Those with sufficient skills to pass a licensing examination may find employment at racetracks.

Employment Outlook

Employment of blacksmiths is expected to decline through the mid-1980's. Forge shops are using machines to produce many of the metal articles that were formerly handmade by blacksmiths. In addition, welders are doing much of the metal repair work once done by blacksmiths. Nevertheless, some job openings will occur as experienced blacksmiths retire, die, or leave the occupation for other reasons.

Employment of farriers may increase slightly due to the growing popularity of horseracing and the increasing use of horses for recreational purposes. Since this is a small occupation, however, relatively few job openings will become available.

Earnings and Working Conditions

In union contracts covering a number of blacksmiths in steel plants and in the shipbuilding and petroleum industries, hourly pay ranged from $4 to $7.50 in 1976. Earnings of blacksmiths in railroad shops averaged $6.87 an hour in 1976. According to limited information, yearly earnings of farriers who shoed saddle horses averaged between $10,000 and $12,000 a year in 1976; those who shoed racehorses averaged around $15,000 a year.

Blacksmith shops tend to be hot and noisy, but conditions have improved in recent years because of large ventilating fans and less vibration from new machines. Blacksmiths are subject to burns from forges and heated metals and cuts and bruises from handling tools. Safety glasses, metal-tip shoes, face shields, and other protective devices have helped to reduce injuries.

The jobs of some farriers may be seasonal. During the summer months, when horses are ridden more often, farriers may work long hours and even on weekends. Also, those who specialize in shoeing racehorses often work at several different racetracks within their area and, therefore, must travel a great deal. In areas where horseracing is seasonal, they may have to move to another State during the off season.

Many blacksmiths are members of the International Brotherhood of Boilermakers, Iron Shipbuilders, Blacksmiths, Forgers and Helpers. Other unions representing blacksmiths include the United Steelworkers of America, the Industrial Union of Marine and Shipbuilding Workers of America, and the International Union of Journeymen Horseshoers.

Sources of Additional Information

For details about training opportunities in this trade, contact local blacksmith shops and local offices of the State employment service.

FORGE SHOP OCCUPATIONS

Forging is one of the oldest methods of working and shaping metals. The exceptional strength of forged metal parts makes this an often used method of forming products that must withstand heavy wear. Many machine tools such as wrenches and drill bits are forged because they are subjected to constant stress and pressure.

The simplest forging method is hand forging done by a blacksmith. Modern forge shops, however, substitute heavy power equipment and dies (tools that shape metal) for the blacksmith's hammer and anvil. In this way, products can be forged in much greater quantity. Five employees operating a large forging machine can turn out more forgings in an hour than five blacksmiths can make in a year.

Most forgings are steel; but aluminum, copper, brass, bronze, and other metals also are forged. Nonferrous forgings are useful in many critical applications, for example, aircraft landing gear. Some of the advantages of nonferrous metal forgings are corrosion resistance and a lighter weight to strength ratio.

Forged products may be as small and lightweight as a key, or they may be as bulky and heavy as a piece of industrial machinery.

Nature of the Work

Before metal can be shaped, it must be heated in intensely hot fur-

naces (forges) until it is soft. Workers place the heated metal between two metal dies that are attached to power presses or hammers. With tremendous force, the hammers or presses pound or squeeze the metal into the desired shape. To finish the forging, other workers remove rough edges and excess metal and perform other finishing operations such as heat treating and polishing.

Two kinds of dies are used. The open die is flat and similar to the blacksmith's hammer, and is used when only a limited quantity of forgings or large-size, simple-shaped forgings are needed. The impression, or closed die, has a cavity shaped to the form of the metal part, and is used to produce large quantities of identical forgings.

Basic forge-shop equipment consists of various types of hammers, presses, dies, upsetters, and furnaces. Forge-shop workers also use handtools, such as hammers and tongs, to help mold and shape parts to fit exact specifications. Measuring devices such as rules, scales, and calipers are needed to inspect the finished products.

Descriptions of some major forge-shop production occupations follow.

Hammersmiths (D.O.T. 612.381) direct the operation of open die power hammers. They follow blueprints and interpret drawings and sketches so that the part being forged will meet specifications. Hammersmiths determine how to position the metal under the hammer and which tools are needed to produce desired angles and curves. They decide the amount of hammer force and if and when the metal needs additional heating.

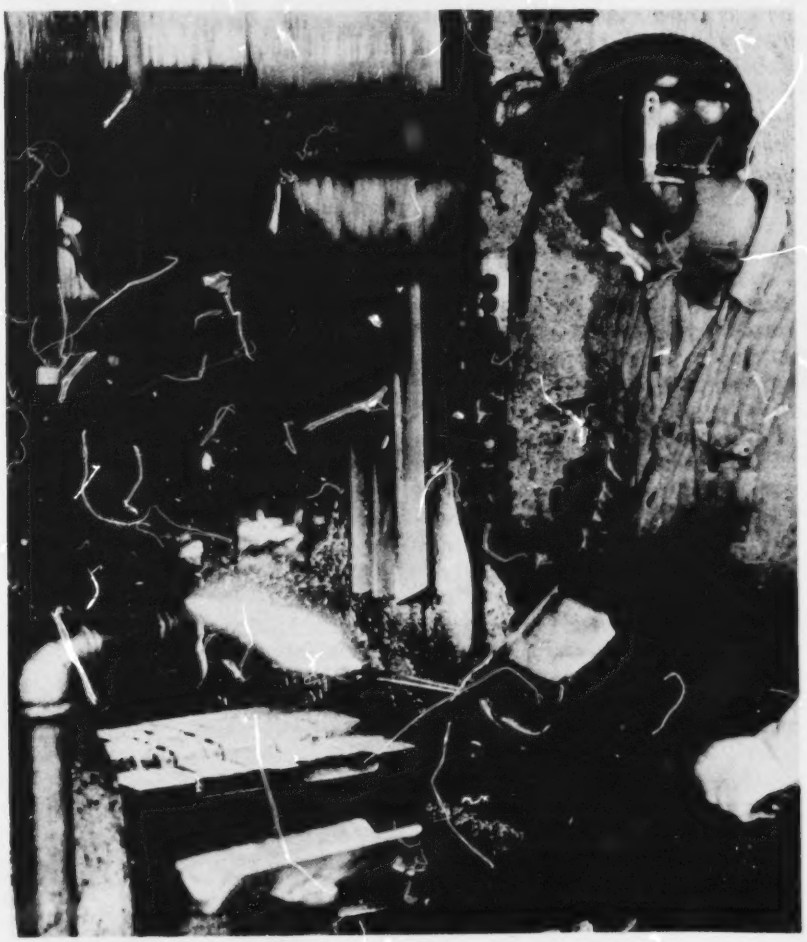
Hammersmiths head crews of four or more workers. A typical crew includes a hammer driver or hammer runner who regulates the force of the forging blow; a crane operator who transfers the metal from the furnace to the hammer and properly places it under the hammer; and a heater who controls the furnace that heats the metal to correct temperatures. The rest of the crew consists of one or more helpers to assist as needed.

The duties of *hammer operators* (D.O.T. 610.782), who operate impression die power hammers, are similar to those just described for hammersmiths. Generally the parts forged by closed die hammers are more intricate and detailed, thus these operators are highly skilled. With the assistance of a crew of helpers and heaters, hammer operators set and align dies in the hammers. They correctly position the metal under the hammer, control the force of the forging blow, and determine if and when the metal needs additional heating to make it easier to shape the metal to that of the die impression.

Press operators (D.O.T. 611.782 and .885) control huge presses equipped with either impression or open dies. These machines press and squeeze hot metal rather than hammer or pound it, and the operators regulate machine pressure and move the hot metal between the dies. They also may control the metal heating operations. Some operators set up the dies in the presses, using instruments such as squares and micrometers to make sure these are in place. Their skills are very similar to those of hammersmiths or hammer operators.

With the help of heaters and several helpers, *upsetters* (D.O.T. 611.782) operate machines that shape hot metal by applying horizontal pressure. The heads of nails and bolts, for example, are made by upset forging.

Heaters (D.O.T. 619.782) control furnace temperatures. They determine when the metal has reached the correct temperature by observing the metal's color and the furnace's tem-



Hammer operator shaping metal parts.

perature gauge. Using tongs or mechanical equipment, they transfer the hot metal from the furnace to hammers or presses. Some heaters clean furnaces.

Inspectors (D.O.T. 612.281) examine forged pieces for accuracy, size, and quality. They use tools such as gauges, micrometers, squares, and calipers to measure the exact dimensions of the forgings. Machines that test strength and hardness and electronic testing devices also may be used.

Die sinkers (D.O.T. 601.280) make the impression dies for the forging hammers and presses. Working from a blueprint, drawing, or template, these skilled workers make an outline of the object to be forged on two matching steel blocks. They measure and mark the object's shape in the blocks to form the impression cavity by using milling machines and other machine tools such as EDM (electrical discharge machinery) and ECM (electrical chemical machinery). Using handtools such as scrapers and grinders, and measuring tools such as calipers and micrometers, die sinkers smooth and finish the die cavity to fit specifications. Finally, a sample is prepared from the finished cavity and is checked against specifications.

Many forge-shop workers clean and finish forgings. For example, *trimmers* (D.O.T. 617.885) remove excess metal with presses equipped with trimming dies. *Grinders* (D.O.T. 705.884) remove rough edges with power abrasive wheels. *Sandblasters* or *shotblasters* (D.O.T. 503.887) operate sandblasting or shotblasting equipment that cleans and smoothes forgings. *Picklers* (D.O.T. 503.885) dip forgings in an acid solution to remove surface scale and reveal any surface defects. *Heat treaters* (D.O.T. 504.782) heat and cool forgings to harden and temper the metal.

Places of Employment

In 1976, about 71,000 production workers were employed in forge shops. About three-fourths of these worked in shops that make and sell forgings. The remainder worked in plants that use forgings in their final products, such as plants operated by manufacturers of automobiles, farm equipment, and handtools.

Although forge-shop workers are found in all areas, they are concentrated near steel-producing centers that provide the steel for forgings, and near metalworking plants that are the major users of forged products. Large numbers of forge-shop workers are employed in and around the cities of Detroit, Chicago, Cleveland, Los Angeles, and Pittsburgh.

Training, Other Qualifications, and Advancement

Most forge-shop workers learn their skills on the job. They generally join hammer or press crews as helpers or heaters, and progress to other jobs as they gain experience. Advancement to hammersmith, for example, requires several years of on-the-job training and experience.

Some forge shops offer apprenticeship training programs for skilled jobs such as diesinker, heat treater, hammer operator, hammersmith, and press operator. These programs usually last 4 years, and offer classroom training and practical experience in metal properties, power hammer and furnace operation, handtool use, and blueprint reading.

Training requirements for inspectors vary. Only a few weeks of on-the-job training are necessary for those who examine forgings visually or use only simple gauges. Others who inspect forgings that must meet exact specifications may need some background in blueprint reading and mathematics, and may be given several months of training.

Employers usually do not require a high school diploma, but graduates may be preferred. Persons interested in more skilled forge-shop jobs should complete high school and take mathematics (especially geometry), drafting, and shopwork.

Although cranes are used to move very large objects, forge-shop workers must be strong enough to lift and move heavy forgings and dies. They also need stamina and endurance to work in the heat and noise of a forge shop.

Employment Outlook

Employment of forge-shop production workers is expected to increase more slowly than the average for all occupations through the mid-1980's. Some new jobs will become available because of growth, but most openings will arise from the need to replace experienced workers who or transfer to other fields of work.

Employment will grow because of expansion in industries that use forgings, particularly automobile and energy-related industries. The expansion of nuclear power plant construction will cause a great demand for forged piping and fittings. Likewise, many forged drilling bits and other forged products will be needed for oil drilling and coal mining operations. However, employment will not keep pace with forge shop production because improved forging techniques and equipment will result in greater output per worker.

Employment in some forge shops is sensitive to changes in economic conditions. In shops that make automobile parts, for example, employment fluctuates with changes in the demand for new cars; thus, jobs in these shops may be plentiful in some years, scarce in others.

Earnings and Working Conditions

Average hourly earnings of forge-shop production workers are higher than the average for all manufacturing production workers. In 1976, production workers in iron and steel forging plants averaged $6.86 an hour, compared to $5.19 an hour for production workers in all manufacturing industries.

Forge-shop occupations are more hazardous than most manufacturing occupations. However, improvements in machinery and shop practices have reduced some noise and vibration. For example, many forge shops have heat deflectors and ventilating fans to reduce heat and smoke. Also, labor and management cooperate to encourage good work practices through safety training and the required use of protective equipment such as face shields, ear plugs, safety glasses, metal-toed shoes, helmets, and machine safety guards.

Most forge-shop workers are union members. Many are members of the International Brotherhood of Boilermakers, Iron Shipbuilders, Blacksmiths, Forgers and Helpers. Others are members of the United Steelworkers of America; the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America; the International Association of Machinists and Aerospace Workers; and the International Die Sinkers' Conference (Ind).

Sources of Additional Information

For information on employment opportunities in forging, contact local offices of the State employment service, personnel departments of forge shops, locals of the labor organizations listed above, or:

The Forging Industry Association, 55 Public Square, Cleveland, Ohio 44113.

The Open Die Forging Institute, 102 Pageant Ave., Rogers, Ark. 72756.

WELDERS

(D.O.T. 810. through 819.887)

Nature of the Work

Welding consists of joining pieces of material, usually metal, by fusing or bonding them together. It is the most common method of permanently connecting metal parts that go into the construction of automobiles, spacecraft, ships, household appliances, construction equipment, and thousands of other products. Beams and steel reinforcing rods in bridges, buildings, and roads frequently are joined by welding. In addition, a growing number of plastic parts are welded to make a variety of products.

Welding processes differ in the way heat is created and applied to the parts being joined. In arc welding, the most frequently used process, heat is created as electricity flows across a gap from the tip of the welding electrode to the metal. In resistance welding, heat is created by resistance to the flow of current through the metal. In gas welding, the combustion of burning gases melts the metal. As part of many welding processes, filler materials, called welding electrodes or welding rods, are melted and added to the joint to give it greater strength. When the heat is removed, the metal and filler material solidify and join the parts. It is the welder's job to control the heat and the weld pool size and to add the filler material so that together they form a strong joint.

Since welding processes differ and are used for a wide variety of purposes, the equipment used and the skill levels of welders vary. Jobs vary from those of highly skilled manual welders who can use gas and electric arc welding equipment in more than one position and who can plan their work from drawings or other specifications to those of unskilled welding machine tenders who simply press a button to start the welding machine. Skilled welders know the material characteristics and properties of steel, aluminum, and other metals and can weld joints in all positions. For example, maintenance welders, pipe welders, and many of the welders who construct ships are skilled welders.

Ship welders join the steel plates, beams, and pipes used to build ships. Some welded joints are on the floor, some are on the wall, and some are overhead. All must be carefully welded to insure that the ship will not break apart in rough seas.

Ship welders generally use arc welding equipment, although gas equipment also is used in many areas. After reading instructions or specifications to learn which materials and welding method to use and obtaining supplies from the storage area, ship welders are ready to begin work. When employing shielded metal arc welding they use a rod in a holder attached to an electric cable coming from a welding power supply. The other power supply cable is attached to the metal being welded which completes the electrical circuit and controls are adjusted to provide the correct amount of welding current. When the power is turned on they "strike an arc" by briefly touching the rod to the metal to start the electricity flowing and then pulling the rod back to create a small gap which the current must jump. If the distance between the rod and the metal is correct, an arc will jump across the space; the heat from the electric arc melts the rod and the metal. Welders control the arc movement along the joint. As the rod melts and becomes shorter they move the holder closer to the metal to keep the correct arc length. When the rod becomes very short, it is discarded and replaced with a new one.

Maintenance welders repair tools, machines, and equipment—for example, a leaking pipe. In such cases, welders may bring their equipment to the job. Gas welding is used in many cases because electrical power may not be available and the torch, hoses, and tanks of gas are portable.

After examining the pipe and preparing the break for repair—usually by grinding—maintenance welders select the proper welding filler rod for the job. Next, they light the torch and adjust regulators on the tanks of fuel gas, such as acetylene, hydrogen, etc., and oxygen to obtain the right gas mixtures and flame. With the filler rod in one hand and the torch in the other, they heat the edges of the break and apply the heat. As the metal begins to melt, the welders periodically melt the end of the filler rod in the hot, liquid metal while they carefully move the torch and rod along the crack to complete the repair. Welders must be careful to keep the torch at the right distance from the metal in order to apply the heat correctly and to add filler material, as needed, to fill the crack.

Not all welders have the skills required of shipbuilding or maintenance welders. For example, less skilled workers use semiautomatic arc welding equipment to speed up the job of welding automobile frames. Semiautomatic equipment consists of a welding gun that welders must manipulate but which automatically supplies the proper amount of arc heat and filler material to the joint. In this case, assembly lines bring car frames to welders and put them in place. Welders then position their welding guns on the parts to be welded and operate a switch on the handle which automatically "strikes

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n arc". They guide the arc to complete one or two joints before the assembly line takes the frame to another worker. Like other welders, they are responsible for the soundness of the joint. However, they need less skill because all parts they weld are identical and each is welded in the same position.

If the factory is large, and many identical parts are to be welded, the company may save money by using automatic welding machines. Such machines may be used, for example, in making automobile mufflers and washing machines. The workers who operate these machines need little knowledge of welding and are frequently called welding machine operators to distinguish them from more skilled, manual welders. Welding machine operators place the parts to be joined in holders on the machine. To complete the weld, operators simply push a button. The machine then clamps the part in place and rotates it, as necessary, to complete the welding cycle. After the welding cycle is finished, operators remove the welded parts and load the machine again.

Closely related to welders are cutters. Cutters use the heat from burning gases or an electric arc to cut and trim metal rather then join it. Some cutters operate electrically or mechanically controlled machines that automatically follow the proper guideline.

Places of Employment

About 660,000 welders and flame cutters were employed in 1976, including a relatively small number of cutters who used both flame and arc-cutting equipment. Almost two-thirds of all welders help manufacture durable goods; for example, boilers, bulldozers, trucks, ships, and heavy machinery. Most of the rest repair metal products or help construct bridges, large buildings, and pipelines.

Welders are concentrated in the manufacturing centers of the Great Lakes States. About one-third work in Pennsylvania, Ohio, Michigan, Indiana, and Illinois. Because of the widespread use of welding, the rest are distributed much the same as the

Jobs for welders are concentrated in the manufacturing centers of the Great Lakes States.

population is with large numbers working in New York, Texas, Wisconsin, and California.

Training, Other Qualifications, and Advancement

Generally, it takes several years of training to become a skilled welder. Some of the less skilled jobs, however, can be learned on the job in a few months. Some welding machine operators, for example, learn to operate a machine in a few hours and become completely qualified in a week.

Beginners often start in simple production jobs where the type and thickness of the metal and the position of the welding operation rarely change. As the need arises, supervisors or experienced workers teach new employees how to weld different types of metals, and how to weld vertical and overhead joints. Many large companies conduct programs to train people as welders. After completing the course, individuals are offered jobs. A few companies offer employees welder apprenticeship programs that last several years, including classroom and on-the-job training.

Persons planning careers as welders or cutters need manual dexterity, good eyesight, and good eye-hand coordination. They should be able to concentrate on detailed work for long periods, and should be free of any physical disabilities that would prevent them from bending, stooping, and working in awkward positions. Most employers prefer applicants who have high school or vocational school training in welding. Courses in shop mathematics, mechanical drawing, blueprint reading, physics, and chemistry also are helpful.

New developments are requiring new skills of welders. This is particularly true in fields such as atomic energy or aerospace manufacturing, which have high standards for the reliability of welds. Before being assigned to work on buildings, bridges, pipelines, or other jobs where the strength of the weld is highly critical, welders may be required to pass an examination of their welding skills given by an employer or government agency. Welders who pass such examinations generally are referred to as "certified welders."

Promotion opportunities for welders are good. Some welding machine operators learn skilled welding jobs; skilled welders may be promoted to welding inspectors, technicians, or supervisors. Experienced workers who have obtained college training on the properties of metals often become welding engineers and are in great demand to develop new application for welding. A small number of experienced welders open their own welding repair shops.

Employment Outlook

Job opportunities for welders should be very good in the years ahead. Employment in this large field is expected to increase faster than the average for all occupations through the mid-1980's. The faster increase will be caused by the generally favorable long run outlook for

metalworking industries and by the greater use of welding in particular. In addition to openings created by employment growth, many jobs should arise each year because of the need to replace experienced welders who retire, die, or transfer to other occupations. Job opportunities may vary from year to year, however, because employment of welders in the manufacturing and construction industries fluctuates with ups and downs in the economy.

Increases in population and income are expected to stimulate demand for cars, buildings, heavy machinery, appliances, and thousands of other products that welders help make. Employment of welders also is expected to increase as welding replaces other methods of joining metals. Welding generally is cheaper than other methods of joining metal parts, and it is being used more frequently in the manufacturing and construction industries.

Earnings and Working Conditions

National wage data on welders are not available. However, the limited data available indicate that welding machine operators earned from $3.93 to $5.10 in 1976. Welders in the construction industry earned $6 to $12 an hour, depending on location.

Welders and cutters use protective clothing, safety shoes, goggles, helmets with protective lenses, and other devices to prevent burns and eye injuries. Although lighting and ventilation usually are adequate, welders occasionally work in the presence of toxic gases and fumes created when some metals melt. They are often in contact with rust, grease, and dirt on metal surfaces. Welding machine operators are largely free from the hazards associated with manual welding. A face shield or goggles generally offer adequate protection to these workers.

Many welders are union members. However, because welding also is done by other craft workers, for example by pipefitters, and only recently has received recognition as a distinct craft, welders belong to many different unions. Among these are the International Association of Machinists and Aerospace Workers; the International Brotherhood of Boilermakers, Iron Shipbuilders, Blacksmiths, Forgers and Helpers; the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America; the United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada; and the United Electrical, Radio and Machine Workers of America (Ind.).

Sources of Additional Information

For further information on training and work opportunities for welders, contact local employers or the local office of the State employment service. For general information about welders, write to:

The American Welding Society, 2501 NW. 7th St., Miami, Fla. 33125.

International Union, United Automobile, Aerospace and Agricultural Implement Workers of America, 8000 East Jefferson Ave., Detroit, Mich. 48214.

FOUNDRY OCCUPATIONS

Many of the products that we use every day are made by casting or have parts that are made by casting. Casting is a method of forming metal into intricate shapes by pouring molten metal into carefully prepared molds and allowing it to solidify. Foundry workers produce metal castings for numerous industrial household products that range from machine tools and automobiles to bathtubs.

The *patternmaker*, the *molder*, and the *coremaker* each play an important part in the process. A *patternmaker* makes a wood or metal model of the casting. A *molder* places it in a box and packs sand around the model to form a mold. If the casting is to have a hollow section, a *coremaker* makes a core of packed and hardened sand that is positioned in the mold before the molten metal is poured in.

In 1976, about 18,000 patternmakers, 53,000 molders, and 22,000 coremakers worked in the foundry industry. About three-fourths of them worked in shops that make and sell castings. The remainder worked in plants that make castings to use in their final products, such as plants operated by manufacturers of automobiles or machinery.

A high school education is the minimum requirement for an apprenticeship in patternmaking. Some highly skilled molding and coremaking jobs also may require a high school education, but an eighth grade education may be enough for entry into many molding and coremaking jobs.

The production and use of castings are expected to grow significantly through the mid-1980's. However, because of automation and other laborsaving improvements in production methods, employment of patternmakers, coremakers, and molders is expected to increase only about as fast as the average for all occupations. In addition to those job openings that result from employment growth, other openings will arise from the need to replace experienced workers who die, retire, or transfer to other occupations. The number of openings may fluctuate from year to year because foundry employment is very sensitive to ups and downs in the economy.

Patternmakers, molders, and coremakers are discussed in detail in the following statements. (For a general description of many other jobs involved in metal casting, see the statement on foundries elsewhere in the *Handbook*.)

Sources of Additional Information

For details about training opportunities for patternmakers, molders, and coremakers, contact local foundries, the local office of the State employment service, the nearest office of the State apprenticeship agency,

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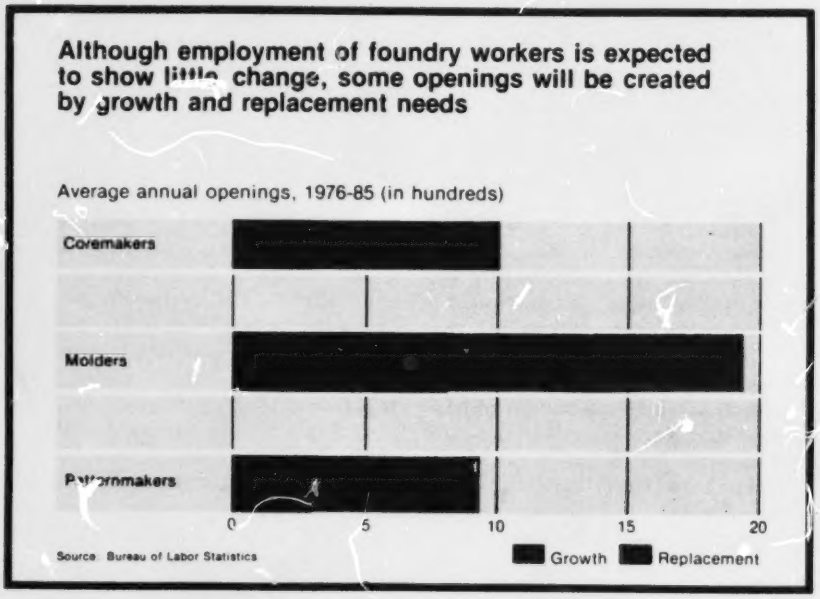


or the Bureau of Apprenticeship and Training, U.S. Department of Labor. Information also is available from the following organizations:

American Foundrymen's Society, Golf and Wolf Rds., Des Plaines, Ill. 60016.

International Molders' and Allied Workers' Union, 1225 E. McMillan St., Cincinnati, Ohio 45206.

PATTERNMAKERS

Nature of the Work

Foundry patternmakers are highly skilled craftworkers who make the patterns used in making molds for metal castings. Most of the workers in the occupation are *metal patternmakers* (D.O.T. 600.280); a smaller number are *wood patternmakers* (D.O.T. 661.281). Some patternmakers work with both metal and wood as well as with plaster and plastics.

Patternmakers work from blueprints prepared by engineers or drafters. They make a precise pattern for the product, carefully checking each dimension with instruments such as micrometers and calipers. Precision is important because any imperfections in the pattern will be reproduced in the castings made from it.

Wood patternmakers select the wood stock, lay out the pattern, and saw each piece of wood to size. They then shape the rough pieces into final form with various woodworking machines, such as lathes and sanders, as well as many small handtools. Finally, they assemble the pattern segments by hand, using glue, screws, and nails.

Metal patternmakers prepare patterns from metal stock or from rough castings made from a wood pattern. To shape and finish the patterns, they use many metalworking machines, including lathes, drill presses, shapers, milling machines, power hacksaws, and grinders. They also use small handtools, such as files and rasps.

Training, Other Qualifications, and Advancement

Apprenticeship is the best means of qualifying as an experienced patternmaker. Because of the high degree of skill and the wide range of knowledge needed for patternmaking, it is difficult to learn the trade on the job, but in some instances skilled machinists have been able to transfer to metal patternmaking with additional on-the-job training or experience. High school courses in mechanical drawing, blueprint reading, and shop mathematics are helpful to persons interested in becoming patternmakers. In addition, vocational and technical school training in patternmaking, metalworking, and machining provide useful preparation for an apprentice, and may be credited toward completion of the apprenticeship.

The usual apprenticeship period for patternmaking is 5 years; however, a few apprenticeships last only 3 or 4 years. Each year at least 144 hours of classroom instruction usually are provided. Apprenticeship programs for wood and metal patternmaking are separate. Employers almost always require apprentices to have a high school education.

Apprentices begin by helping experienced patternmakers in routine duties. They make simple patterns under close supervision; as they progress, the work becomes increasingly complex and the supervision more general. Patternmakers earn higher pay as their skill increases, and some become supervisors.

Patternmaking, although not strenuous, requires considerable standing and moving about. Manual dexterity is especially important because of the precise nature of the work. The ability to visualize objects in three dimensions also is important when reading blueprints.

Employment Outlook

Employment of foundry patternmakers is expected to increase only about as fast as the average for all occupations through the mid-1980's despite the anticipated large increases in foundry production. The increased use of metal patterns will allow production to increase faster than employment. Metal patterns, unlike wooden ones, can be used again and again, thus reducing the number of patterns that have to be made.

In addition to those openings created by employment growth, some job openings will arise because of the need to replace experienced patternmakers who retire, die, or transfer to other occupations. Most of these openings will be for metal patternmakers. The number of openings may fluctuate from year to year since

Patternmakers must carefully check each dimension.

the demand for foundry products is sensitive to changes in the economy.

Because patternmakers learn either basic metalworking or woodworking, they are prepared for jobs in related fields when patternmaking employment is not available. Wood patternmakers can qualify for woodworking jobs such as cabinetmaker, and metal patternmakers can transfer their skills to metalworking jobs such as machinist.

Earnings and Working Conditions

Patternmakers generally have higher earnings than other production workers in manufacturing. In January 1976, average straight-time hourly earnings of wood patternmakers ranged from $6 in gray iron and malleable iron foundries, to $6.25 in nonferrous foundries, according to a wage survey made by the National Foundry Association. In comparison, all production workers in manufacturing industries averaged $5.19 an hour.

Patternmakers work indoors in well-lighted, well-ventilated areas. The rooms in which they work generally are separated from the areas where the casting takes place, so they are not exposed to the heat and noise of the foundry floor.

For sources of additional information, see the introductory section of this chapter.

MOLDERS

Nature of the Work

One of the oldest known methods of making metal products is by metal casting, or the process of pouring molten metal into a previously made mold and allowing the metal to harden in the shape of the mold. There are several different ways of making molds, but sand molding is the most common. In sand molding, molders make the mold by packing and ramming specially prepared sand around a pattern—a model of the object to be duplicated—in a box called a flask. A flask usually is made in two parts that can be separated to remove the pattern without damaging the mold cavity. When molten metal is poured into the cavity, it solidifies and forms the casting. (Other types of molds and molding processes are described in the foundry industry section of the *Handbook*).

Technologically advanced molding machines that pack and ram the sand mechanically are now used to make most molds. Thus, most of the workers in this occupation are machine molders. *Machine molders* (D.O.T. 518.782) operate machines that speed up and simplify the making of large quantities of identical sand molds. Machine molders assemble the flask and pattern on the machine table, fill the flask with prepared sand, and operate the machine with levers and pedals. Many of these workers set up and adjust their own machines.

In a few foundries, hand molders still construct the sand molds, using primarily manual methods. Power tools, such as pneumatic rammers, and handtools, such as trowels and mallets, are used to smooth the sand. Molds for small castings usually are made on the workbench by *bench molders* (D.O.T. 518.381); those for large and bulky castings are made on the foundry floor by *floor molders* (D.O.T. 518.381). An all-round hand molder makes many different types of molds. A less skilled molder specializes in a few simple types.

Training, Other Qualifications, and Advancement

Completion of a 4-year apprenticeship program, or equivalent experience, is needed to become a skilled hand molder. Workers with this training also are preferred for some kinds of machine molding, but in general a shorter training period is required in order to become a qualified machine molder. Some people learn molding skills informally on the job, but this way of learning the trade takes longer and is less reliable than apprenticeship.

An eighth grade education usually is the minimum requirement for ap-

Molders need good vision and manual dexterity.

prenticeship. Many employers, however, prefer high school graduates.

Apprentices, under close supervision by skilled molders, begin with simple jobs, such as shoveling sand, and then gradually take on more difficult and responsible work, such as ramming molds, withdrawing patterns, and setting cores. They also learn to operate the various types of molding machines. As their training progresses, they learn to make complete molds. In addition, the apprentice may work in other foundry departments to develop all-round knowledge of foundry methods and practices. The apprentice usually receives at least 144 hours of classroom instruction each year in subjects such as shop arithmetic, metallurgy, and shop drawing.

Hand molders who do highly repetitive work that requires less skill usually learn their jobs during a brief training period. Trainees work with a molder to make a particular kind of mold. After 2 to 6 months, the trainee usually is capable of making a similar mold. Most machine molding jobs can be learned in 2 to 3 months on the job.

Physical standards for molding jobs are fairly high. Hand molders stand while working, must move about a great deal, and frequently must lift heavy objects. They need good vision and a high degree of manual dexterity. Molders may advance to a specialized molding job or eventually to a supervisory position.

Employment Outlook

Employment of molders is expected to increase about as fast as the average for all occupations through the mid-1980's. Although the demand for metal castings is expected to increase significantly, the trend to more machine molding, such as the sand slinging process, and other laborsaving innovations will allow large increases in production with only moderate employment growth. In addition to job openings created by employment growth, openings will arise from the need to replace experienced molders who retire, die, or transfer to other occupations. The number of openings, however, may fluctuate greatly from year to year because the demand for foundry products is sensitive to changes in the economy.

Earnings and Working Conditions

In January 1976, floor molders averaged $5.52 an hour and bench molders averaged $4.98, according to a wage survey made by the National Foundry Association. By comparison, production workers in all manufacturing industries averaged $5.19 an hour. Molders who were paid on an incentive basis generally had higher earnings.

Working conditions vary considerably from one foundry to another. Heat, fumes, and dust, have been greatly reduced in many plants by the installation of improved ventilation systems and air-conditioning; however, in many older foundries these still are problems.

Working in a foundry can be hazardous, and the injury rate is higher than the average for all manufacturing industries. Safety programs and safety equipment, such as metal-plated shoes, have helped reduce injuries at many foundries; however, molders must be careful to avoid burns from hot metal and to avoid cuts and bruises when handling metal parts and power tools.

For sources of additional information, see the introductory section of this chapter.

COREMAKERS

Nature of the Work

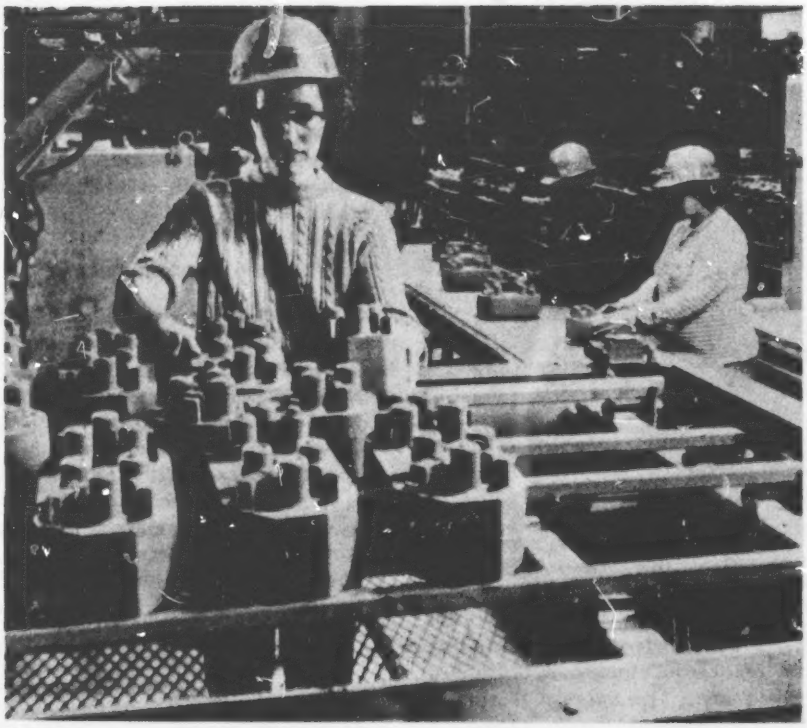
Coremakers prepare the "cores" that are placed in molds to form the hollow sections in metal castings. The poured metal solidifies around the core, so that when the core is removed the desired cavity or contour remains.

A core may be made either by hand or by machine. In both instances, sand is packed into a block of wood or metal in which a space of the desired size and shape has been hollowed out. After the core is removed from this box, it is hardened by baking or by another drying method. When hand methods are used, the coremaker uses mallets and other handtools to pack sand into the core box. Small cores are made on the workbench by *bench coremakers* (D.O.T. 518.381) and large ones are made on the foundry floor by *floor coremakers* (D.O.T. 518.381).

Machine coremakers (D.O.T. 518.885) operate machines that make sand cores by forcing sand into a core box. Some machine coremakers are required to set up and adjust their machines and do finishing operations on the cores. Others are primarily machine tenders. They are closely supervised and their machines are adjusted for them. (To see how the coremaker's job is a basic step in the casting process, read the description of sand casting given in the statement on foundries elsewhere in the *Handbook*.)

Training, Other Qualifications, and Advancement

Completion of a 4-year apprenticeship training program or the equivalent experience is needed to become a skilled hand coremaker. Apprenticeships also are sometimes required for the more difficult machine coremaking jobs. Apprenticeships in coremaking and molding often are combined.



Coremaker operating machine that produces cores for automobile engine heads.

Experienced coremakers teach apprentices how to make cores and operate ovens. Classroom instruction covering subjects such as arithmetic and the properties of metals generally supplements on-the-job training. Coremakers earn higher pay as their skill increases, and some may advance to supervisors.

An eighth grade education usually is the minimum requirement for coremaking apprentices; however, most employers prefer high school graduates, and some employers require apprentices to have graduated from high school. Some types of hand coremaking require a high degree of manual dexterity.

Employment Outlook

Although the production and use of metal castings are expected to increase substantially, employment of coremakers is expected to increase only about as fast as the average for all occupations through the mid-1980's, as the growing use of machine coremaking will allow large increases in production with only moderate employment growth. In addition to those job openings created by employment growth, other openings will arise because of the need to replace experienced coremakers who retire, die, or transfer to other occupations. The number of openings may fluctuate greatly from year to year since the demand for foundry products is sensitive to changes in the economy.

Earnings and Working Conditions

In January 1976, average hourly earnings of floor coremakers were $5.30; bench coremakers, $5.28; and machine coremakers, $5.31, according to a wage survey made by the National Foundry Association. By comparison, production workers in all manufacturing industries averaged $5.19 an hour. Coremakers who were paid on an incentive basis generally had higher earnings than those who were paid a straight hourly wage.

Working conditions vary considerably from one foundry to another. Heat, fumes, and dust, have been greatly reduced in many plants by the installation of improved ventilation systems and air-conditioning. Although the injury rate in foundries is higher than the average for manufacturing, coremaking is one of the least hazardous foundry jobs.

For sources of additional information, see the introductory section of this chapter.

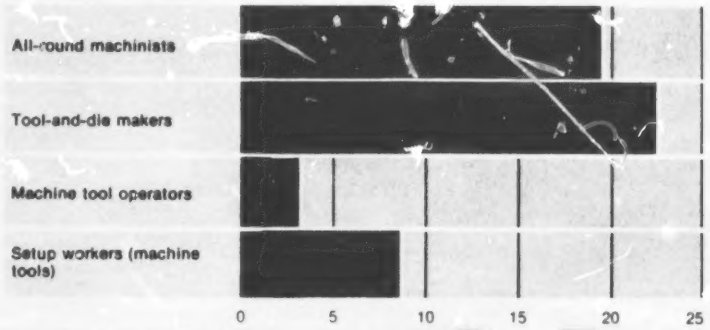
MACHINING OCCUPATIONS

Machine tools are stationary, power-driven devices used to shape or form metal by cutting, impact, pressure, electrical techniques, or a combination of these processes. Most machine tools are named for the way in which they shape metal. For example, commonly used machine tools include boring machines, milling machines, lathes, drilling machines, and grinding machines. In 1976, over 1.1 million machinists, machine tool operators, tool-and-die makers, setup workers, and instrument makers used machine tools to make precise metal parts.

The most outstanding characteristic of machine tools is their precision of operation. For example, in this century the accuracy of machine tools has improved from a thousandth of an inch to about a millionth of an inch. A millionth of an inch is about 1/300th as thick as a human hair. This precision makes possible the production of thousands of identical parts which may easily be interchanged in the assembly or repair of final products. The interchangeability of parts made possible by machine tools the most important requirement mass production of goods. As a result arly every product of American ind , from corn-

Technological advances will limit growth in all machining occupations. However, highly skilled machinists and tool-and-die makers will not be affected as much as less skilled operators and setup workers

Selected machining occupations
Average annual openings, 1976-85 (in thousands)



Source: Bureau of Labor Statistics

flakes to turbines, is made either using machine tools or using machines made with machine tools.

All-round machinists can operate most types of machine tools, whereas machine tool operators generally work with one kind only. Tool-and-die makers make dies (metal forms) for presses and diecasting machines, devices to guide drills into metal, and special gauges to determine whether the work meets specified tolerances. Instrument makers use machine tools to produce highly accurate instrument parts from metal and other materials. Setup workers adjust tools for semiskilled machine tool operators to run. (Detailed discussions of work performed, training, and earnings of these occupations are presented in the chapters that follow.)

ALL-ROUND MACHINISTS

(D.O.T. 600.280, .281, and .381)

Nature of the Work

All-round machinists are skilled metal workers who can perform a wide variety of machining operations. They are able to set up and operate most types of machine tools used to make metal parts for cars, machines, and other equipment. Machinists also know the working properties of a variety of metals including steel, cast iron, aluminum, brass, and other metals. This knowledge of metals, plus their ability to work with machine tools, enables machinists to turn a block of metal into an intricate part meeting precise specifications.

All-round machinists plan and carry through all the operations needed to make a machined product. They also often are able to switch from making one product to another; as a result, variety is a major feature of all-round machinists' work.

Before they begin actually making a machined product, machinists usually consult blueprints or written specifications for the item. Using these, they are able to select tools and materials for the job and plan the cutting and finishing operations. They also make standard shop computations relating to dimensions of work and machining specifications. To be sure their work is accurate, they check it using precision instruments, such as micrometers, which measure to thousandths or even millionths of an inch. After completing machining operations, they may use hand files and scrapers to smooth rough metal edges before assembling the finished parts with wrenches and screwdrivers.

Like production machinists, all-round machinists who work in plant maintenance shops have a broad knowledge of mechanical principles and machining operations. These workers are responsible for repairing parts or making new parts for machinery that has broken down. They sometimes also adjust and test the parts they have made or repaired for a machine.

Places of Employment

About 400,000 persons worked as machinists in 1976. Almost every factory using substantial amounts of machinery employed all-round machinists to maintain its mechanical equipment. Some all-round machinists made large quantities of identical parts such as automobile axle shafts in production departments of metalworking factories; others made limited numbers of varied products such as missile motor cases in machine shops.

Most all-round machinists worked in the following industries: machinery, including electrical; transportation equipment; fabricated metal products; and primary metals. Other industries employing substantial numbers of these workers were the railroad, chemical, food processing, and textile industries. The Federal Government also employed all-round machinists in Navy yards and other installations.

Although machinists work in all parts of the country, jobs are most plentiful in areas where many factories are located. Among the leading areas of employment are Los Angeles, Chicago, New York, Philadelphia, Boston, San Francisco, and Houston.

Training, Other Qualifications, and Advancement

A 4-year formal apprenticeship is the best way to learn the machinist trade, but some companies have training programs for single-purpose machines that require less than 4 years to complete. Many machinists do learn this trade on the job, however.

Persons interested in becoming machinists should be mechanically inclined and temperamentally suited to do highly accurate work that re-

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Most machinists work in factories that produce metal products such as automobiles and machinery.

quires concentration as well as physical effort. Prospective machinists should be able to work independently. Although the work sometimes is tedious and repetitious, all-round machinists frequently have the satisfaction of seeing the final results of their work.

A high school or vocational school education, including mathematics, physics, or machine shop training, is desirable. Some companies require experienced machinists to take additional courses in mathematics and electronics at company expense so that they can service and operate numerically controlled machine tools. In addition, equipment builders generally provide training in the electrical, hydraulic, and mechanical aspects of machine-and-control systems.

Typical machinist apprentice programs consist of approximately 8,000 hours of shop training and about 570 hours of related classroom instruction. In shop training, apprentices learn chipping, filing, hand tapping, dowel fitting, riveting, and the operation of various machine tools. In the classroom, they study blueprint reading, mechanical drawing, shop mathematics, and shop practices.

All-round machinists have numerous opportunities for advancement. Many become supervisors. Some take additional training and become tool-and-die or instrument makers. Skilled machinists may open their own shops or advance into other technical jobs in machine programming and tooling.

Employment Outlook

The number of all-round machinists is expected to increase at about the same rate as the average for all occupations through the mid-1980's. Growth in the demand for machined metal parts will cause most of the increase. In addition to openings created by growth in this large occupation, many openings will arise from the need to replace experienced machinists who retire, die, or transfer to other fields of work.

As population and income rise, so will the demand for machined goods, such as automobiles, household appliances, and industrial products. However, technological developments that increase the productivity of machinists are expected to keep employment from rising as fast as the demand for machined goods.

Chief among these technological innovations is the expanding use of numerically controlled machine tools. These machines, which use computers to control various machining operations, significantly reduce the time required to perform machining operations.

Much of the employment growth will occur in the maintenance shops of manufacturing plants as industries continue to use a greater volume of complex machinery and equipment. More skilled maintenance machinists will be needed to prevent costly breakdowns in highly mechanized plants. Often the breakdown of just one machine can stop an entire production line for hours.

Earnings and Working Conditions

The earnings of machinists compare favorably with those of other skilled workers. Machinists employed in metropolitan areas had estimated average hourly earnings of $6.76 in 1976. Average hourly rates in 10 of the areas surveyed, selected to show how wage rates differ in var-

ious parts of the country, appear in the accompanying tabulation. Because machinists work indoors, they are able to work year round and in all kinds of weather. As a result, their earnings are relatively stable. Many also receive numerous opportunities for overtime work.

Area	*Hourly rate*
San Francisco—Oakland	$7.82
Detroit	7.61
New York	7.39
Houston	7.23
Chicago	7.19
Minneapolis—St. Paul	6.87
Atlanta	6.65
Dallas—Fort Worth	6.60
Boston	6.33
New Orleans	6.18

Machinists must follow strict safety regulations when working around high-speed machine tools. Short-sleeved shirts, safety glasses, and other protective devices are required to reduce accidents. Most shops are clean and workplaces are well-lighted.

Many machinists are members of unions including the International Association of Machinists and Aerospace Workers; the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America; the International Union of Electrical, Radio and Machine Workers; the International Brotherhood of Electrical Workers; and the United Steelworkers of America.

Sources of Additional Information

The National Machine Tool Builders Association, 7901 Westpark Dr., McLean, Va. 22101—whose members build a large percentage of all machine tools used in this country—will supply, on request, information on career opportunities in the machine tool industry.

The National Tool, Die and Precision Machining Association, 9300 Livingston Rd., Oxon Hill, Md. 20022, offers information on apprenticeship training, including recommended apprenticeship standards for tool and die makers certified by the U.S. Department of Labor's Bureau of Apprenticeship and Training.

The Tool and Die Institute, 777 Busse Highway, Park Ridge, Ill. 60068—a trade association—offers information on apprenticeship training in the Chicago area.

Many local offices of State employment services provide free aptitude testing to persons interested in becoming all-round machinists or tool and diemakers. In addition, the State employment service refers applicants for apprentice programs to employers. In many communities, applications for apprenticeship also are received by labor-management apprenticeship committees.

Apprenticeship information also may be obtained from the following unions (which have local offices in many cities):

International Association of Machinists and Aerospace Workers, 1300 Connecticut Ave. NW., Washington, D.C. 20036.

International Union, United Automobile, Aerospace and Agricultural Implement Workers of America, Skilled Trades Department, 8000 East Jefferson Ave., Detroit, Mich. 48214.

International Union of Electrical Radio and Machine Workers, 1126 16th St. NW., Washington, D.C. 20036.

INSTRUMENT MAKERS (MECHANICAL)

(D.O.T. 600.280)

Nature of the Work

Instrument makers (also called experimental machinists and model-makers) are among the most skilled of all machining workers. They work closely with engineers and scientists to translate designs and ideas into experimental models, special laboratory equipment, and custom instruments. Experimental devices constructed by these craft workers are used, for example, to regulate heat, measure distance, record earthquakes, and control industrial processes. The parts and models may range from simple gears to intricate parts of navigation systems for guided missiles. Instrument makers also modify existing instruments for special purposes.

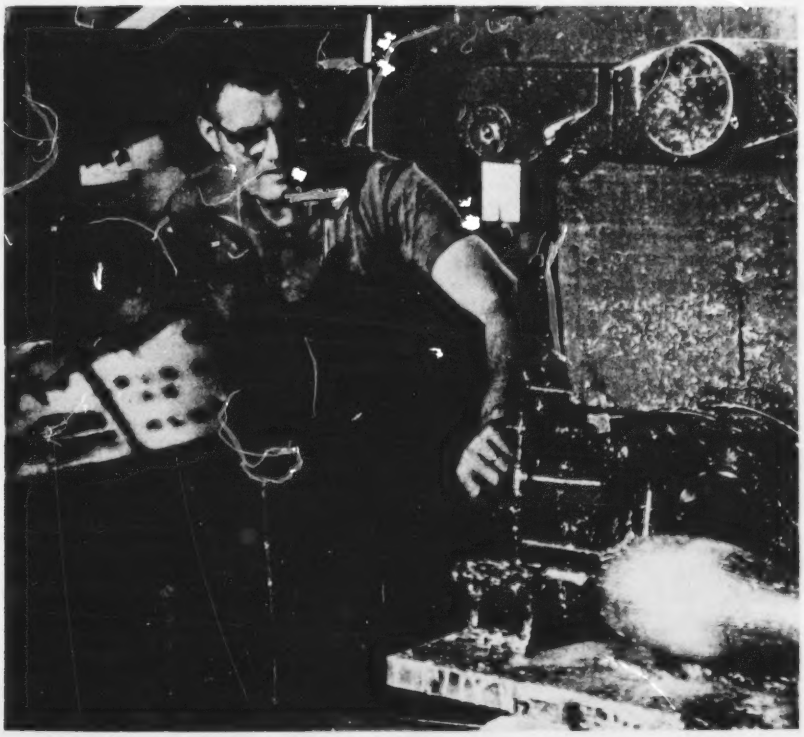
Instrument makers perform many tasks similair to those done by all-round machinists, tool-and-die makers, and setup workers. For example they may set up and use machine tools such as lathes and milling machines to fabricate metal parts for the instruments they make. In addition, they use handtools such as files and chisels to smooth rough metal parts. As in other types of machining work, accuracy is important. Like most machining workers, instrument makers measure finished parts to make sure they meet specifications, using a wide variety of precision measuring equipment, including micrometers, verniers, calipers, and dial indicators, as well as standard optical measuring instruments.

Unlike other skilled machining workers, instrument makers often are not given detailed instructions, such as blueprints, for their work. Instead, they may work from rough sketches or verbal instructions, or they may simply be given a concept to work with. As a result, their work often requires considerable imagination and ingenuity. In addition they must often work to finer tolerances than other machining workers. Sometimes specifications must not vary more than 10 millionths of an inch. To meet these standards, they use special equipment or precision devices, such as the electronic height gauge, which other machining workers seldom use. They also work with a wider variety of materials than other machining workers. These materials include plastics and rare metals such as titanium and rhodium.

In some instances, instrument makers work on instruments from start to finish. That is, they make all the parts, assemble them, and then test the finished product. However, in large shops, or where time is important, the work may be divided among a number of workers. Similarly, if an instrument has electrical or electronic components, electronic specialists may be consulted.

Places of Employment

Many of the approximately 6,000 instrument makers employed in 1976 worked for firms that manufactured instruments. Others were in research



Instrument makers work closely with engineers and scientists.

and development laboratories that make special devices for scientific research. The Federal Government employed many instrument makers.

The main centers of instrument making are located in and around a few large cities, particularly New York, Chicago, Los Angeles, Boston, Philadelphia, Washington, Detroit, Buffalo, and Cleveland.

Training, Other Qualifications, and Advancement

Some instrument makers advance from the ranks of machinists or skilled machine tool operators. These already skilled craft workers begin by doing the simpler instrument making tasks under close supervision. Usually 1 to 2 years or more of instrument shop experience are needed to qualify as instrument makers.

Other instrument makers learn their trade through apprenticeships that generally last 4 years. A typical 4-year program includes 8,000 hours of shop training and 576 hours of related classroom instruction. Shop training emphasizes the use of machine tools, handtools, and measuring instruments, and the working properties of various materials. Classroom instruction covers related technical subjects such as mathematics, physics, blueprint reading, chemistry, metallurgy, electronics, and fundamental instrument design. Apprentices must learn enough shop mathematics to plan their work and to use formulas. A basic knowledge of mechanical principles is needed in solving gear and linkage problems.

For apprenticeship programs, employers generally prefer high school graduates who have taken algebra, geometry, trigonometry, science, and machine shopwork. Further technical schooling in electricity, physics, machine design, and electronics often is desirable, and may make possible future promotions to technician jobs.

Persons interested in becoming instrument makers should have a strong interest in mechanical subjects and better than average ability to work with their hands. They must have initiative and resourcefulness because instrument makers often work with little or no supervision. Since instrument makers often face new problems, they must be able to develop original solutions. Frequently, they must visualize the relationship between individual parts and the complete instrument, and must understand the principles of the instrument's operation. Because of the nature of their jobs, instrument makers have to be very conscientious and take considerable pride in creative work.

As instrument makers' skills and knowledge improve, they may advance to more responsible positions. For example, they may plan and estimate time and material requirements for the manufacture of instruments or provide specialized support to professional personnel. Others may become supervisors and train less skilled instrument makers.

Employment Outlook

Employment in this very small occupation is expected to increase at about the same rate as the average for all occupations through the mid-1980's. Most openings, however, will occur as workers retire, die, or leave the occupation for other reasons. Overall, replacement needs will be small because there are so few workers in this field.

Some workers will be needed to make models of new instruments for mass production and also to make custom or special instruments, particularly in the expanding field of industrial automation. Also, more versatile and sensitive precision instruments can be expected to emerge from current research and development programs. Laborsaving technological innovations, however, will limit employment growth. Numerically controlled machine tools, for example, reduce the amount of labor required in machining operations.

Earnings and Working Conditions

Earnings of instrument makers compare favorably with those of other highly skilled metalworkers. In 1976, instrument makers generally earned about $7 an hour.

Instrument shops usually are clean and well-lighted, with temperatures strictly controlled. Instrument assembly rooms are sometimes known as "white rooms," because almost sterile conditions are maintained.

Serious work accidents are not common, but machine tools and flying metal particles may cause finger, hand, and eye injuries. Safety rules generally require the wearing of special glasses, aprons, tightly fitted clothes, and short-sleeved shirts.

Many instrument makers are union members. Among the unions representing them are the International Association of Machinists and Aerospace Workers; the International Brotherhood of Electrical Workers; and the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America.

Sources of Additional Information

See the list under this same heading in the previous statement on all-round machinists.

MACHINE TOOL OPERATORS

(D.O.T. 602., 603., 604., 605., and 606.)

Nature of the Work

Machine tool operators use machine tools such as lathes, drill presses, milling machines, grinding machines, and punch presses to shape metal to precise dimensions. Although some operators can work with a wide variety of machine tools, most specialize in one or two types.

Operators fall into two broad skill categories—semiskilled and skilled. Semiskilled operators are essentially machine tenders who perform simple, repetitive operations that can be learned relatively quickly. Skilled operators can perform varied and complex machining operations. Both skilled and semiskilled operators have job titles related to the kind of machine they operate, such as milling machine operator and drill press operator.

Most machine tool operators fall into the semiskilled category. Their jobs vary according to the type of machine they work with; however, there are many tasks common to most machine tools. Typically, semiskilled operators place rough metal stock in a machine tool on which the speeds and operation sequence already have been set by skilled workers. By using special, easy-to-use gauges they watch the machine and make minor adjustments. However, they depend on skilled machining workers for major adjustments when their machine is not working properly.

The work of skilled machine tool operators is similar to that of all-round machinists, except that it usually is limited to only one type of machine and involves little or no hand fitting or assembly work. Skilled machine tool operators plan and set up the correct sequence of machining operations according to blueprints, layouts, or other instructions. They adjust speed, feed, and other controls, and select the proper cutting instruments or tools for each operation. Using micrometers, gauges, and other precision measuring instruments, they compare the completed work with the tolerance limits given in the specifications. They also may select cutting oils to keep the metal workpiece from getting too hot and lubricating oils to keep the machine tools running smoothly.

Machine tool operators must adjust machines with precision.

Places of Employment

More than 500,000 machine tool operators were employed in 1976. Most worked in factories that produce fabricated metal products, transportation equipment, and machinery in large quantities. Skilled machine tool operators also worked in production departments, maintenance departments, and toolrooms.

Machine tool operators work in every State and in almost every city in the United States. They are concentrated, however, in major industrial areas such as the Great Lakes Region. About one-fourth of all machine tool operators work in the Great Lakes cities of Detroit, Flint, Chicago, Cleveland, and Milwaukee. Among the other areas that have large numbers of these workers are Los Angeles, Philadelphia, St. Louis, and Indianapolis.

Training, Other Qualifications, and Advancement

Most machine tool operators learn their skills on the job. Beginners usually start by simply observing experienced operators at work. Later they learn to use measuring instruments and to make elementary computations needed in shopwork. When trainees first operate a machine, they are supervised closely by more experienced workers. After gaining some experience themselves, beginners often take over more of the duties associated with the tools they operate. For example, they may learn to adjust feed speeds and cutting edges, instead of calling upon other workers to perform these tasks. Some also may learn to read blueprints and plan the sequence of machining work.

Individual ability and effort largely determine the time required to become a machine tool operator. Most semiskilled operators learn their jobs in a few months, but becoming a skilled operator often requires 1 to 2 years. Some companies have formal training programs for new employees.

Although no special education is required for semiskilled jobs, persons seeking such work can improve their opportunities by completing courses in mathematics and blueprint reading. In hiring beginners, employers often look for persons with mechanical aptitude and some experience working with machinery. Physical stamina is important since much time is spent standing. Applicants should be able to work independently. They also should not mind working in a relatively small workspace. Although much of the work is tedious, many machine tool operators derive satisfaction from seeing the results of their work.

Skilled machine tool operators may become all-round machinists, tool-and-die makers, or advance to jobs in machine programming and maintenance.

Employment Outlook

Job opportunities for machine tool operators should be fairly plentiful in the years ahead. Employment in the occupation is expected to increase about as fast as the average for all occupations through the mid-1980's. In addition to openings arising from growth, many thousands of openings are expected to occur each year in this large occupation as operators retire, die, or transfer to other fields of work.

More machine tool operators will be needed as metalworking industries expand their output. However, the use of faster and more versatile automatic machine tools and numerically controlled machine tools will result in greater output per worker and tend to limit employment growth. Other factors that may slow growth in this occupation are the increasingly important new processes in metalworking, such as electrical discharge and ultrasonic machining, and the use of powdered metals that reduce the machining necessary for a final product.

Workers with thorough backgrounds in machining operations, mathematics, blueprint reading, and a good working knowledge of the properties of metals will be better able to adjust to the changing job requirements that will result from technological advances.

Earnings and Working Conditions

Machine tool operators are paid according to hourly or incentive rates, or on the basis of a combination of both methods. Highly skilled operators in metropolitan areas had estimated hourly earnings of $7.11 in 1976. This compares favorably with the average for nonsupervisory workers in private industry, except farming. Average hourly rates in 10 of the areas surveyed, selected to show how wage rates of machine tool operators differ in various parts of the country, appear in the accompanying tabulation.

Area	*Hourly rate*
Detroit	$7.89
Cleveland	7.30
Chicago	7.14
St. Louis	6.93
Baltimore	6.84
Cincinnati	6.34
Houston	6.30
Minneapolis—St. Paul	6.18
Dallas—Fort Worth	6.12
Boston	5.76

Most shops are clean and workplaces are well-lighted. Machine tool operators must use protective glasses to protect their eyes from flying metal particles. They cannot wear loose-fitting garments as these might get caught in the machine, injuring the operator or causing damage to the machine.

Most machine tool operators belong to unions, including the International Association of Machinists and Aerospace Workers; the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America; the International Union of Electrical, Radio and Machine Workers; the International Brotherhood of Electrical Workers; and the United Steelworkers of America.

Sources of Additional Information

See the list under this same heading in the statement on all-round machinists elsewhere in the *Handbook*.

SETUP WORKERS (MACHINE TOOLS)

(D.O.T. 600.380)

Nature of the Work

Machine tools used in shops that do machining in large volume usually are both very large and very complex. Setup workers, often called machine tool job setters, are skilled workers who specialize in preparing these tools for use. Most setup workers work on only one type of machine, such as a drill press or lathe; however, some set up several different kinds.

Before they begin preparing a machine for use, setup workers consult blueprints, written specifications, or job layouts. From these they can determine how fast the material to be machined should be fed into the machine, operating speeds, tooling, and the order in which the machine will perform its operations (operation sequence). They then select and install the proper cutting or other tools and adjust guides, stops, and other controls.

After setting up the machine, they usually make a trial run to be sure that it is running smoothly and producing parts that conform to specifications. When they are sure the machine is functioning properly, they explain to semiskilled operators how to run the machine and how to be sure that the machine's output meets specifications. They then turn the machine over to the semiskilled operators to begin production.

Places of Employment

In 1976, an estimated 60,000 setup workers were employed in factories that manufactured fabricated metal products, transportation equipment, and machinery. Most worked for large companies that employed many semiskilled machine tool operators. Setup workers usually are not employed in maintenance shops or in small jobbing shops.

Setup workers are found in every State. However, employment is concentrated in major industrial areas such as Los Angeles, Philadelphia, New York, Chicago, Detroit, and Cleveland.

Setup worker in a turret lathe operation.

Training, Other Qualifications, and Advancement

Setup workers must meet the same qualifications as all-round machinists. They must be able to operate one or more kinds of machine tools and select the sequence of operations so that metal parts will be made according to specifications. The ability to communicate clearly is important in explaining the machining operations to semiskilled workers. Setup workers may advance within a shop to supervisory jobs or transfer into other jobs, such as parts programmer.

Employment Outlook

Employment of setup workers is expected to increase about as fast as the average for all occupations through the mid-1980's. Although consumer and industrial demand for machined goods will grow, partly offsetting this will be greater productivity of setup workers due to the increasing use of numerically controlled machined tools. In these machine tools, cutting sequences, feed speeds, tool selection, and other operations are controlled by a computer. Most job opportunities will arise from the need to replace experienced workers who retire, die, or transfer to other occupations.

Earnings and Working Conditions

The earnings of setup workers compare favorably with those of other skilled machining workers. In 1976, setup workers in metropolitan areas had average earnings of about $7 an hour.

Because they work with high-speed machine tools that have sharp cutting edges, setup workers must follow certain safety practices. For example, they cannot wear loose-fitting clothes as these might get caught in the machine and they must wear safety goggles to protect their eyes from flying metal particles.

Many setup workers are members of unions, including the International Association of Machinists and Aerospace Workers; the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America; and the United Steelworkers of America.

Sources of Additional Information

See the list under this same heading in the statement on all-round machinists elsewhere in the *Handbook*.

TOOL-AND-DIE MAKERS

(D.O.T. 601.280, .281, and .38[illegible])

Nature of the Work

Tool-and-die makers are highly skilled, creative workers whose products—tools, dies, and special guiding and holding devices—are used by other machining workers to mass-produce metal parts. Toolmakers produce jigs and fixtures (devices that hold metal while it is shaved, stamped, or drilled). They also make gauges and other measuring devices used in manufacturing precision metal parts. Diemakers construct metal

forms (dies) to shape metal in stamping and forging operations. They also make metal molds for diecasting and for molding plastics. Tool-and-die makers also repair worn or damaged dies, gauges, jigs, and fixtures, and design tools and dies.

Compared with most other machining workers, tool-and-die makers have a broader knowledge of machining operations, mathematics, and blueprint reading. Like machinists, tool-and-die makers use almost every type of machine tool and precision measuring instrument. Because they work with all the metals and alloys commonly used in manufacturing, tool-and-die makers must be familiar with the machining properties, such as heat tolerance, of a wide variety of metals and alloys.

Places of Employment

More than 180,000 tool-and-die makers were employed in 1976. Most worked in plants that produce manufacturing, construction, and farm machinery. Others worked in automobile, aircraft, and other transportation equipment industries; small tool-and-die shops; and electrical machinery and fabricated metal industries.

Although tool-and-die makers are situated throughout the country, jobs are most plentiful in areas where many large factories are located. About one-fifth of all tool-and-die makers work in the Detroit and Flint, Chicago, and Los Angeles areas, which are major manufacturing centers for automobiles, machinery, and aircraft, respectively. Among the other areas that have large numbers of these workers are Cleveland, New York, Newark, Dayton, and Buffalo.

Tool-and-die makers must have a broad knowledge of machine operations.

Training, Other Qualifications, and Advancement

Tool-and-die makers obtain their skills in a variety of ways including formal apprenticeship, vocational school, and on-the-job training. Formal apprenticeship programs, however, are probably the best way to learn the trade.

In selecting apprentices, most employers prefer persons with a high school or trade school education. Applicants should have a good working knowledge of mathematics and physics, as well as considerable mechanical ability, finger dexterity, and an aptitude for precise work. Some employers test apprentice applicants to determine their mechanical aptitudes and their abilities in mathematics.

Most of the 4 years of a tool-and-die apprenticeship are spent in practical shop training. Apprentices learn to operate the drill press, milling machine, lathe, grinder, and other machine tools. They also learn to use handtools in fitting and assembling tools, gauges, and other mechanical equipment, and study heat treating and other metalworking processes. Classroom training consists of shop mathematics, shop theory, mechanical drawing, tool designing, and blueprint reading. Several years of experience after apprenticeship are often necessary to qualify for more difficult tool-and-die work. Some companies have separate apprenticeship programs for toolmaking and diemaking.

Some machining workers become tool-and-die makers without completing formal apprenticeships. After years of experience as skilled machine tool operators or machinists, plus additional classroom training, they develop into skilled all-round workers who can make tools and dies.

Skilled tool-and-die makers have numerous paths for advancement. Some advance to supervisory and administrative positons in industry. Many tool-and-die makers become

tool designers and others may open their own tool-and-die shops.

Employment Outlook

Employment of tool-and-die makers is expected to increase at about the same rate as the average for all occupations through the mid-1980's. Most openings, however, will occur as experienced tool-and-die makers retire, die, or transfer to other fields of work.

The long-range expansion in metalworking industries will result in a continued need for tools and dies. The growth of this occupation may be limited, however, by the use of electrical discharge machines and numerically controlled machines that have significantly changed toolmaking processes. Numerically controlled machining operations require fewer of the special tools and jigs and fixtures, and could increase the output of each tool-and-die maker.

The extensive skills and knowledge of tool-and-die makers can be acquired only after many years of experience. Because of this, tool-and-die makers are able to change jobs within the machining occupations more easily than other less skilled workers.

Earnings and Working Conditions

Tool-and-die makers are among the highest paid machining workers. In 1976, tool-and-die makers employed in metropolitan areas had estimated earnings of $7.21 an hour. This was about one and one-half times as much as the average for all nonsupervisory workers in private industry, except farming. Average hourly rates in 13 of the areas surveyed, selected to show how wage rates for tool-and-die makers differ in various parts of the country, appear in the accompanying tabulation.

As with other machining workers, tool-and-die makers wear protective glasses when working around metal-cutting machines. Tool-and-die shops are usually safer than similar operations in production plants.

Area	*Hourly rate*
San Francisco—Oakland	$8.87
Detroit	7.88
Chicago	7.72
Baltimore	7.61
Cleveland	7.18
Atlanta	7.07
Dallas—Fort Worth	7.00
Cincinnati	6.82
Boston	6.62
Houston	6.61
New York	6.45
Salt Lake City	6.17
Chattanooga	5.56

Many tool-and-die makers are members of unions, including the International Union, United Automobile, Aerospace and Agricultural Implement Workers of America; and the United Steelworkers of America.

Sources of Additional Information

See the list under this same heading in the statement on all-round machinists elsewhere in the *Handbook*.

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What to Look For in this Reprint

To make the *Occupational Outlook Handbook* easier to use each occupation or industry follows the same outline. Separate sections describe basic elements, such as work on the job, education and training needed, and salaries or wages. Some sections will be more useful if you know how to interpret the information as explained below.

The TRAINING, OTHER QUALIFICATIONS, AND ADVANCEMENT section indicates the preferred way to enter each occupation and alternative ways to obtain training. Read this section carefully because early planning makes many fields easier to enter. Also, the level at which you enter and the speed with which you advance often depend on your training. If you are a student, you may want to consider taking those courses thought useful for the occupations which interest you.

Besides training, you may need a State license or certificate. The training section indicates which occupations generally require these. Check requirements in the State where you plan to work because State regulations vary.

Whether an occupation suits your personality is another important area to explore. For some, you may have to make responsible decisions in a highly competitive atmosphere. For others, you may do only routine tasks under close supervision. To work successfully in a particular job, you may have to do one or more of the following:

- motivate others
- direct and supervise others
- work with all types of people
- work with things—you need good coordination and manual dexterity
- work independently—you need initiative and self-discipline
- work as part of a team
- work with details, perhaps numbers or laboratory reports
- help people
- use creative talents and ideas
- work in a confined area
- do physically hard or dangerous work
- work outside in all types of weather

A counselor can help you find out more about your interests and abilities so you can judge whether a job's characteristics suit you.

The EMPLOYMENT OUTLOOK section tells whether or not the job market is likely to be favorable. Usually an occupation's expected growth is compared to the average projected growth rate for all occupations (20.1 percent between 1976 and 1985). The following phrases are used:

Much faster	50% or more
Faster	25.0 to 49.9%
About as fast	15.0 to 24.9%
Slower	4.0 to 14.9%
Little change	3.9 to -3.9%
Decline	-4.0% or more

Generally, job opportunities are favorable if employment is growing at least as fast as for the economy as a whole.

But, you would have to know the number of people competing with you to be sure of your prospects. Unfortunately, this supply information is lacking for most occupations.

There are exceptions, however, especially among professional occupations. Nearly everyone who earns a medical degree, for example, becomes a practicing physician. When the number of people pursuing relevant types of education and training and then entering the field can be compared with the demand, the outlook section indicates the supply/demand relationship as follows:

Excellent	Demand much greater than supply
Very good	Demand greater than supply
Good or favorable	Rough balance between demand and supply
May face competition	Likelihood of more supply than demand
Keen competition	Supply greater than demand

Competition or few job openings should not stop your pursuing a career that matches your aptitudes and interests. Even small or overcrowded occupations provide some jobs. So do those in which employment is growing very slowly or declining.

Growth in an occupation is not the only source of job openings because the number of openings from turnover can be substantial in large occupations. In fact, replacement needs are expected to create 70 percent of all openings between 1976 and 1985.

Finally, job prospects in your area may differ from those in the Nation as a whole. Your State employment service can furnish local information.

The EARNINGS section tells what workers were earning in 1976.

Which jobs pay the most is a hard question to answer because good information is available for only one type of earnings—wages and salaries—and not even this for all occupations. Although 9 out of 10 workers receive this form of income, many earn extra money by working overtime, night shifts, or irregular schedules. In some occupations, workers also receive tips or commissions based on sales or service. Some factory workers are paid a piece rate—an extra payment for each item they make.

The remaining 10 percent of all workers—the self-employed—includes people in many occupations—physicians, barbers, writers, and farmers, for example. Earnings for self-employed workers even in the same occupation differ widely because much depends on whether one is just starting out or has an established business.

Most wage and salary workers receive fringe benefits, such as paid vacations, holidays, and sick leave.

Workers also receive income in goods and services (payment in kind). Sales workers in department stores, for example, often receive discounts on merchandise.

Despite difficulties in determining exactly what people earn on the job, the Earnings section does compare occupational earnings by indicating whether a certain job pays more or less than the average for all nonsupervisors in private industry, excluding farming.

Each occupation has many pay levels. Beginners almost always earn less than workers who have been on the job for some time. Earnings also vary by geographic location but cities that offer the highest earnings often are those where living costs are most expensive.

What's an ad for the OOQ doing in a place like this?

The career information contained in the reprint you are reading was taken from the 1978-79 edition of the Occupational Outlook Handbook. But the Handbook is not the only source of useful career information published by the Bureau of Labor Statistics. The Handbook's companion, the Occupational Outlook Quarterly, is published four times during the school year to keep subscribers up to date on new occupational studies completed between editions of the Handbook. The Quarterly also gives practical information on training and educational opportunities, salary trends, and new and emerging jobs—just what people need to know to plan careers.

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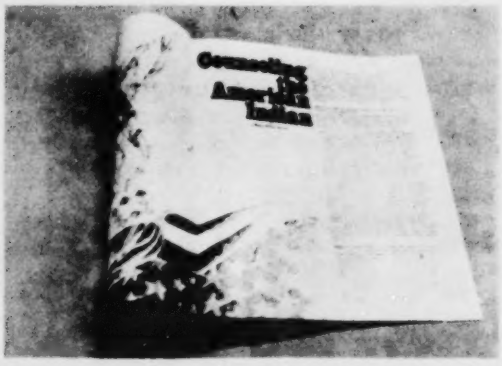

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